Transition mechanisms to turbulence in a cylindrical rotor-stator cavity by pseudo-spectral simulations of Navier-Stokes equations

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The flow above an infinite rotating disk is an example of 3D boundary-layers where crossflow instability can develop as over swept wings. With a second rotating disk parallel to the first, the configuration schematizes the cavity between the disks holding the blades of a turbine or compressor. Centrifugal and Coriolis forces produce a secondary flow in the meridian plane composed of two thin boundary-layers along the disks separated by a non-viscous geostrophic core. That produces adjacent coupled flow regions that are radically different in terms of flow stability and thickness scales involving very challenging simulations. Identify and characterize the transition mechanism is a necessity for developing future efficient control strategies of turbulent rotating boundary layers. The matter of the transition scenario is currently much debated (see in Viaud, Serre & Chomaz JFM 07, APS 2010) around the idea that a global instability might take place and lead to transition to turbulence.

This work addresses the study of coherent structures related to the transition mechanisms in a rotor-stator cavity. An accurate pseudo-spectral algorithm has been developed dealing with the singularity at the centreline of the cylindrical coordinate system ($r;\ \theta;\ z$). The very unstable stator boundary is characterized at moderate Reynolds number by travelling axisymmetric structures that eventually damped close to the axis and localized rotating spiral at the periphery. The much more stable rotor layer seems governed by the same mechanisms than recently identified by Viaud *et al* 2010 of a cascade of global modes leading eventually to turbulence.